STARK AREA REGIONAL TRANSIT AUTHORITY

Project Name	SARTA/OSU Advanced Smart Mobility Deployment
Eligible Entity Applying to Receive Federal Funding	Stark Area Regional Transit Authority
Total Project Cost (from all sources)	$ 5,705,615
ATCMTD Request	$ 2,810,584
Are matching funds restricted to a specific project component? If so, which one?	No
Is the project currently programmed in the: • Transportation Improvement Program (TIP) • Statewide Transportation Improvement Program (STIP) • MPO Long Range Transportation Plan • State Long Range Transportation Plan	No, but once awarded, the project will be programmed into the: • Transportation Improvement Program (TIP), and • Statewide Transportation Improvement Program (STIP)
Technologies Proposed to Be Deployed (briefly list)	• Autonomous Electric Shuttle Buses • Vehicle-to-Vehicle/ Infrastructure/ Cloud/Pedestrian Communication Equipment • Anaerobic Digestion for Renewable Electricity Generation • Smart Paint and Smart Canes

Project Narrative

1.0 Introduction

1.1 Project Description

The Stark Area Regional Transit Authority (SARTA)—in collaboration with the Ohio State University (OSU) Center for Automotive Research (CAR), the OSU Transportation Research Center, Inc. (TRC), the Pro Football Hall of Fame, the City of Canton, EasyMile, Lyft, CALSTART, Quasar Energy Group, Intelligent Material Solutions (IMS), Digital Buckeye, RoadBotics, Lear, and Teradata—seeks to deploy a holistic and comprehensive smart mobility and energy system aimed at: increasing access for the rural and underprivileged, reducing congestion, reducing carbon and pollutant emissions; increasing energy sustainability; reducing vehicle to vehicle and vehicle to pedestrian accidents; incentivizing travellers to use environmentally friendly modes of transit; and aiding in revitalizing a rust belt city. Key and unique features include building a smart data ecosystem with 15 data sources that will be the foundation of the project, reaching out to the underprivileged in new ways, extensive applications of V2X technology with uses that expand the current envelop, integrating dynamic ride sharing into a comprehensive smart mobility plan for the area, producing sustainable distributed energy / generation with a negative carbon footprint, and applying a novel infrastructure monitoring system (Figure 1). During its trial, the system will impact 29 vehicles, 20 traffic signals, 5200 daily Canton riders, and 1000 OSU daily student users.

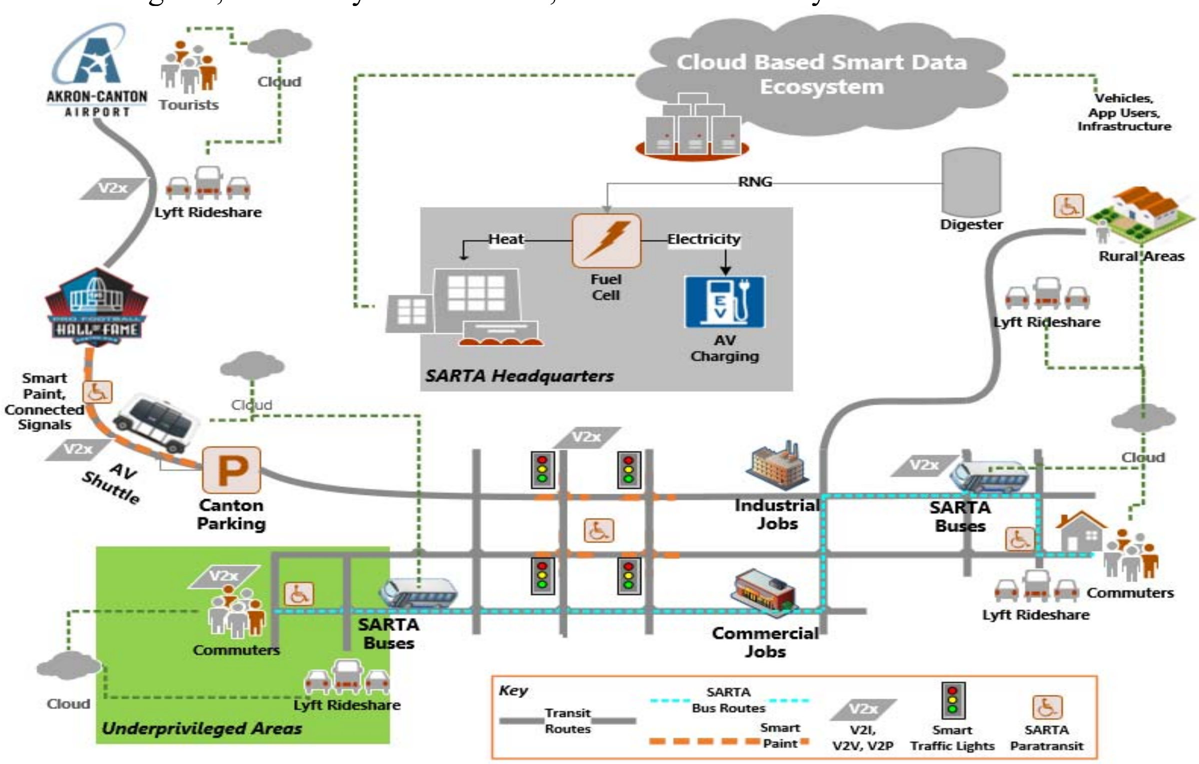

Figure 1. Project schematic.

SARTA will deploy three battery-electric, advanced, zero-emission, autonomous EasyMile shuttle buses along a fixed route between downtown Canton and the newly remodeled Hall of Fame Village, while OSU will deploy one additional autonomous (AV) shuttle on the OSU campus in Columbus, Ohio. The Canton AVs will coordinate with the existing SARTA bus system, multiple dynamic ridesharing vans operated by Lyft, and paratransit vehicles with wheel chair access operated by SARTA. In addition, the project team will equip each of the autonomous vehicles (AVs), 10 of SARTA's existing zero-emission hydrogen fuel cell buses, 10 Lyft ridesharing vans, and five SARTA paratransit vans with Vehicle-to-Infrastructure (V2I), Vehicle-to-Cloud (V2C), Vehicle-to-Pedestrian (V2P), and Vehicle-to-Vehicle (V2V) communication capabilities for system management and improved safety. In addition, Lear will equip 20 traffic signals with controllers to coordinate signals for improved traffic management, and in some cases, for signal preemption. Also, 20 pedestrians will be equipped with communication devices to alert vehicles of their presence to test vehicle avoidance and autonomous breaking. Finally, the project team will install IMS smart paint along the AV route and at four Canton intersections, to enhance AV guidance and provide enhanced location and tracking services for visually impaired persons using smart canes, as endorsed by the Philomatheon Society of the Blind.

Vehicle	**# Vehicles**	**V2X Technologies and Systems**			
		Fully Autonomous	Pedestrian Avoidance	Crash Avoidance	Connected Vehicle
EasyMile Autonomous Shuttle	4	✓	✓	✓	✓
Lyft 6-passenger vans	10		✓	✓	✓
SARTA Fuel Cell Bus (existing)	10		✓	✓	✓
Paratransit Vehicles (existing)	5		✓	✓	✓

Table 1. Summary of Vehicles and V2X Technologies.

Taken as a whole, the project is in exceptional alignment with all of the vision, goals, and focus areas stated in Section A of the Funding Opportunity Announcement. Specifically, the project will deploy 1) a comprehensive transportation solution involving advanced, connected multimodal transportation and 2) a variety of V2X technologies to promote safety, improve travel efficiency, demonstrate technology efficacy, and, in some cases, advance the technology by applying new concepts. It will also implement a cloud-based smart data ecosystem involving collection, storage, and analytics to improve system operation through data analysis, and provide information needed for accurate real-time trip planning. Collectively, these scalable and replicable advanced transit solutions will reduce traffic congestion, optimize traffic flow, enhance transit vehicle safety, support underserved and disadvantaged riders, connect the underprivileged with employment, increase transit vehicle connectedness, deploy and promote the use of environmentally friendly transit options, and support the economic development goals of the City of Canton. The project will also serve as a region-leading model for advanced transit vehicle deployment in cities and universities, as well as for the modernization of Canton and other "Rust Belt" cities across the Midwest's industrial region.

By selecting commercially available technologies—the EasyMile shuttles and the Lyft ridesharing vehicles, proven data collection and analytics by Teradata, known V2X technologies by Lear, technical support by the world class intelligent vehicle group at OSU-CAR, and smart mobility testing by the OSU TRC—SARTA and the project partners anticipate a high likelihood of successfully deploying and sustaining the proposed advanced vehicle technologies. EasyMile's autonomous vehicles currently operate in more than a dozen countries globally, including deployments in California and Texas; its autonomous shuttles have logged more than 1.5 million rides in a safe, reliable, zero-emissions manner that is directly relevant to SARTA's proposed operations under the project. The average service lifetime of these shuttles is four years. During deployment, two of the shuttles will operate along a fixed route between downtown Canton and the new, $650-million Pro Football Hall of Fame Village, which suffers from limited parking and heavy traffic congestion. A third will serve as a backup shuttle. OSU will deploy a fourth driverless shuttle bus on its campus in Columbus, Ohio to provide automated transit connections among campus research laboratories, including the main offices of OSU CAR and CAR-WEST, which specializes in autonomous vehicle research. OSU will also use the AV shuttle to assist the disabled in traveling from parking areas to arenas and other campus facilities used during special events. This is an underserved area of the OSU campus and will benefit greatly from the autonomous shuttle deployment.

Electricity for the proposed battery-electric shuttle buses will be derived from a proposed 300-kW Fuel Cell Energy FCE 300 molten carbonate fuel cell that would be donated by the US Navy as surplus. The fuel cell will operate on 100-percent locally-sourced, renewable natural gas (RNG) produced by an anaerobic digester managed by Quasar Energy Group. SARTA will install the proposed fuel cell system at its headquarters, where it will supply excess power and waste heat from the fuel cell to that facility. Fuel Cell Energy, the fuel cell manufacturer, initiated commercialization of its fuel cell systems in 2008, and has since continued to develop its technology within US and global power supply markets. The proposed fuel cell will be fully inspected and tested prior to installation supporting a very high likelihood of success for this project element. Thus, the project will implement a comprehensive energy solution, achieving nearly 90% RNG-to-energy conversion efficiency, including waste heat recovery, with a negative carbon footprint for automated vehicle charging.

As an important component of the project, SARTA will coordinate with Lyft to deploy dynamic ridesharing vehicles. With a capacity of six passengers each, these vehicles will be operated by Lyft vehicle owners/operators. SARTA will outfit select vehicles with V2C, V2V, V2I, and V2P capabilities to interface (using Lear technology) with project tracking, analytics, and a mobile app user interface. In coordination with SARTA, Lyft will operate these vehicles throughout the Canton area, in part as a ridesharing alternative for trips for the 8,200 daily tourists traveling between the Canton Airport, downtown Canton, and the Hall of Fame Village. SARTA will also use the ridesharing vehicles to assist underserved rural and intercity riders in connecting to SARTA's transit system, and to help residents in disadvantaged communities in SARTA's service area to connect to healthcare, shopping, and, importantly, commercial and industrial job opportunities. Finally, SARTA will have five of its paratransit vans with ADA-compliant wheel chair access, in accordance with the Canton smart mobility plan. All vehicles will be equipped with pedestrian collision avoidance technology to help minimize vehicle-on-pedestrian accidents.

To further enhance the odds of success, while also meeting the goals of the Federal Transit Administration, the project team will deploy a smart data ecosystem with comprehensive analytics and data management capabilities that will allow analysis of the existing ways that people travel, and provide real time information for effective trip planning to improve service, reduce congestion, encourage people to make better transit choices, enhance safety, and increase ridership on SARTA's existing city bus lines. First, SARTA will connect 10 of its existing buses to a cloud-based tracking and data management system, supporting enhanced trip planning using the Canton Smart Transit App. SARTA will make this free, mobile phone app available, following a staged deployment plan, to people moving in the Canton area, including visitors to the Hall of Fame Village. This app will provide information about the timing, cost, and environmental impact of a proposed trip, and will also provide a single-point electronic payment option for entire multimodal trips, even ones that cross jurisdictions.

To coordinate vehicles, help reduce traffic congestion, and support the Canton Smart Transit App, SARTA will also deploy interconnected V2V, V2C, V2P, and V2I vehicle communication systems supporting cloud communication with other intelligent vehicles, and also 20 upgraded smart traffic signal installations. SARTA will also deploy accident avoidance systems on the proposed autonomous vehicles, the Lyft ridesharing vehicles, five SARTA paratransit vans, and 10 existing SARTA buses to prevent vehicle/vehicle, vehicle/pedestrian, and vehicle/bicycle accidents. To support the proposed transit systems, RoadBotics will complete a detailed and automated road assessment, while OSU TRC will complete testing and fine tuning of the proposed autonomous vehicles, V2X and Smart Paint and Smart Cane technologies prior to deployment to ensure their safe and efficient operation and minimize downtime which could jeopardize the project schedule.

SARTA does not foresee any significant legal, institutional, or legislation-related obstacles to the deployment of the proposed shuttle buses and ridesharing vehicles. SARTA also maintains deep experience in deploying advanced vehicle technologies using grant funds, and has successfully received and managed more than $25 million in federal funding for clean transportation vehicle deployments. Therefore, SARTA and the project team members consider the likelihood of project success to be exceptionally high.

The project is highly scalable: relying on commercially available technologies, and proven systems it will install an initial smart data ecosystem for collection, management, and analytics to manage existing and additional connected vehicle technologies, transportation modes and expanded usage as SARTA brings these online within its service area. Furthermore, the proposed autonomous vehicles, as well as safety and connectivity equipment installations, will serve as test deployments, marking a first stage in SARTA's four stage planned deployment of advanced transit and congestion management technologies over the coming years. To this end, the project team is deeply invested in demonstrating and supporting future deployments of advanced transportation vehicles in the Ohio / Rust Belt region and to demonstrate how such a system can be a key part of economic revitalization while providing key access to the underprivileged for jobs and services in cost effective ways. The project will deploy the first fully autonomous on-road transit vehicles in the region, and in new innovative ways, demonstrate smart transit systems and services to create a safer, more accessible, and optimized regional transit system. In this way, deployment of the project will provide a flagship example for the redevelopment, reinvigoration, and greening of the Rust Belt, a region deeply in need of creative thinking, new ideas, and technological development.

To ensure scalability, SARTA is committed to evaluating the effectiveness of the proposed vehicle deployments. To this end, CALSTART will track all project and vehicle related capital and operational costs, and compare these to baseline operations information, represented by the hypothetical use of conventional buses along the same route as the proposed autonomous shuttle buses. SARTA will compare capital and operation costs of the project with baseline data, and will evaluate the cost / benefit of the project including Return on Investment. SARTA will provide results of these analyses to the DOT and to the public, to help demonstrate the level of effectiveness of the proposed vehicles including net cost savings. SARTA will also use these results, along with publicly available traffic data, to plan future expansion of these advanced transportation technologies across SARTA's service area, and to support future smart transit partnerships and technology transfer to other Rust Belt cities and transit authorities.

1.2 Proposed Technology Deployments

The project will provide a complete transit solution in Canton and rural areas of SARTA's service areas through new autonomous shuttle buses, dynamic ridesharing vehicles, city buses, and paratransit vans equipped with new interconnected vehicle and smart system technologies.

Autonomous Shuttle Buses. The project will deploy four new, wholly autonomous, driverless, battery-electric EasyMile Z10 shuttle buses. Three will be deployed in SARTA's service area (two operational and one charging or undergoing maintenance) and one at OSU (see Section 3.0 for locations).

Developed by European vehicle manufacturer Ligier, EasyMile Z10 shuttles are electric people-movers capable of transporting up to 12 people (6 sitting and 6 standing) at a time, with full wheelchair access for reduced mobility passengers. With nearly 10 years of on-road operating experience and prior demonstrations at over 60 prior sites in Europe, Asia, and North America, the Z10 is a well-tested, fully operational, early commercial autonomous vehicle. It has no steering wheel and no dedicated front or back, enabling the vehicle to easily change its direction without turning. The vehicle supports transport speeds of up to 25 miles per hour (mph), and is capable of driving on dedicated roadways as well as lanes shared with street traffic, along a defined route. Propulsion is provided by an electric asynchronous motor, powered by a lithium ion ($LiFePO_4$) battery, which provides up to 14 hours of operation. It features an on-board, 230V / 16-amp battery charger, is approximately 12 feet 10 inches long and 6 feet 6 inches wide, and can carry a payload of 3,750 lbs. The vehicle also features full climate control.

Figure 2. EasyMile Z10 Autonomous Battery-Electric Shuttle Bus

Driving safety of the vehicle is supported by numerous on-board hardware and software systems and programming. First, EasyMile will work directly with SARTA to develop a detailed and standardized driving route for the proposed buses, including all stops. During use, the vehicle's multiple on-board cameras, radar, differential global positioning systems (DGPS), laser-based sensors, and odometry sensors (which estimate change in position over time) support 360-degree detection. These sensors are combined with advanced software to support localization techniques, obstacle detection and avoidance, anti-collision, emergency stop, and navigation, including path planning and control. The vehicles also feature V2V and V2I connectivity, supporting advanced fleet management, as well as safety and cybersecurity. Autonomous braking will also enhance pedestrian safety by engaging when a pedestrian (carrying a mobile

Dedicated Short Range Communications (DRSC) unit) is detected. To date, the vehicles have been successfully deployed in San Ramon, California, as well as Singapore, Finland, France, Italy, Spain, and Switzerland. EasyMile has been developing and deploying autonomous vehicles since 2008, and has logged more than 1.5 million passenger rides during that time without logging a single accident.

Fuel Cell and Renewable Power. SARTA will provide 100 percent renewable power to charge the proposed vehicles using RNG. The RNG will power a 300-kW Fuel Cell Energy FCE 300 molten carbonate fuel cell that will act as a distributed generation power source for recharging the AVs and other electric vehicles in the area. Waste heat from the fuel cell will also heat and cool the SARTA headquarters building, to provide distributed generation with a negative carbon footprint at over 90 percent efficiency. The stationary fuel cell will be installed at SARTA's headquarters. It will operate continuously, providing power for vehicle charging, while also supplying electricity and heating for daily ongoing operations at SARTA's headquarters and for recharging other EVs in the area. If successful in winning this grant, the project team will finalize coordination with the US Navy to obtain the fuel cell which is sitting unused in storage as surplus – free of charge.

An existing community-scale digester located in Zanesville, Ohio will provide RNG for the project. The existing digester produces renewable biogas from a variety of organic feedstocks, including wastewater biosolids, food waste, and yard clippings. Biogas from the facility will be routed into a gas cleaning and compression /upgrading skid to produce RNG for injection into a natural gas pipeline that is adjacent to Quasar's digester site. The RNG will then be transported to SARTA's headquarters. SARTA will enter a pending commodity agreement with Quasar to ensure a consistent supply of RNG. SARTA will also acquire RIN credits for the RNG through a pending agreement with Quasar.

On-Demand Ridesharing Vehicles. Lyft will operate ridesharing vehicles in the Canton area and test them in four elements of the Canton transit system by providing the Canton Smart Transit App to : (1) incoming tourists (for their trips between the airport and the Hall of Fame Village or downtown Canton – a trip of about 10 miles); (2) on-demand ridesharing vehicles to connect rural riders with Canton and its surrounding communities; (3) on-demand ridesharing services to connect people from disadvantaged areas in Canton and its surrounding communities with area services; and, (4) typical daily commuters. All ridesharing vehicles will be equipped with V2V, V2C, and V2I communications, as well as collision avoidance systems to prevent accidents with vehicles and pedestrians. Lyft drivers will own and operate the vehicles, and SARTA will outfit 10 of the ridesharing vans with the proposed communication and collision avoidance equipment. Typically, these vehicles will be either four- or six-passenger vans. To additionally serve the disadvantaged, five ADA-compliant SARTA paratransit vans—similarly equipped with V2C, V2I, V2P and V2V—will be deployed to serve both rural and urban riders.

City Bus Ridership, Safety, and Congestion Management Upgrades. SARTA's existing city buses form the backbone of its urban transit system. The project seeks to increase ridership and safety on SARTA's existing, zero-emissions fuel cell buses by connecting the buses to the cloud to coordinate trip planning using the Canton Smart Transit App (see below). In addition, bus safety will be significantly enhanced (see below), and transit times reduced using vehicle-to-traffic signal coordination, and V2V communications and accident avoidance systems.

Canton Smart Transit App. SARTA will deploy a free mobile app based on existing apps used by Lyft, as well as the cities of Boston and St. Petersburg, to encourage the use of rapid and multimodal, environmentally friendly public transit by tourists, commuters, urban disadvantaged and rural riders, and other transit users. The app will coordinate individual transit experiences across SARTA's system. Riders will input their start and end points into the app, which will provide several transit solutions for each trip, along with comparisons for each alternative based on cost, travel time, safety, and environmental footprint. Once a transit selection has been made, the app will make appropriate reservations and schedule the trip. The focus of the app will be to provide reliable, optimized travel times to enhance ease of use and encourage ridership, while identifying environmentally friendly transit options available to users. Riders will also be able to pay for an entire transit trip, directly from the app (i.e., single point of electronic payment), even where the trip may reach across several transit modes and districts. The app will also identify the most environmentally friendly transit route, and include an incentive program to encourage users to choose that route over less environmentally friendly options. The project team will develop the app based on an existing platform similar to that used by Lyft for the City of Boston.

Interconnected Vehicles and Data Analytics. Applicable vehicles (Table 1) will be cloud-connected and will interface with transit users, other intelligent vehicles, and infrastructure, including traffic signals. To this end, the project will include the installation of 20 Econolite traffic signal controllers. Data generated by interconnected vehicles, on-ground city resources, reference data, and other transit data sources will be managed by a cloud based integrated smart data ecosystem (Section 5.0) deployed by Teradata that will track the locations of ridesharing vehicles, buses, paratransit vans and autonomous vehicles to allow for effective trip planning and to enable the Canton Smart Transit App. These system-generated data will be further integrated with publicly available traffic movement data to plan future enlargement and optimization of the proposed advanced transit system through interface with Teradata's proposed smart data ecosystem and analytics (see below).

Enhanced Safety Equipment. SARTA will outfit each autonomous shuttle bus, 10 of the Lyft dynamic ridesharing vehicles, 10 zero-emission fuel cell buses, and the five paratransit vans with advanced safety equipment designed to minimize V2V and V2P accidents. In addition to the safety and collision avoidance technologies standard in EasyMile's Z10 system (see above), SARTA will also outfit the autonomous shuttles with V2V communications, V2P autonomous braking, and V2I communications to enhance coordination with and allow preemption of traffic signals. Ridesharing vehicles, 10 existing buses, and 5 paratransit vehicles will also include V2V communications for collision avoidance with other intelligent vehicles, as well as V2P restraint systems and V2I communications to enhance coordination with traffic signals. To enhance safety above and beyond standard practice, the project team will install an IMS smart paint demonstration along the autonomous vehicle route to ensure the AV remains on course, and to make its route highly visible to other traffic. Smart paint will also be applied at select Canton intersections. AVs will detect this paint and use it to stay in the correct lanes along dedicated routes. Smart paint will also be detectable by visually impaired persons using smart canes that will identify their location based on the pavement markings (at crosswalks and bus stops).

SARTA will provide smart canes to four visually impaired users to support project demonstration. The canes will also provide pedestrian location data to vehicles equipped with pedestrian avoidance.

LoNo Vehicles. The project will utilize only low- and zero-emission vehicles for the proposed technology and advanced transportation system deployments operated by SARTA. The autonomous shuttle buses will be battery-electric and powered by renewable energy; the SARTA paratransit vans, powered by hybrid-electric, compressed natural gas (CNG), or hydrogen fuel cell systems; and the existing buses used by SARTA for the project will be fuel cell or CNG systems powered by renewable natural gas. Therefore, the project will strongly support air pollutant and carbon emissions reductions within SARTA's transit system.

Road Infrastructure Assessment. RoadBotics will complete a comprehensive road infrastructure assessment for 150 miles of roadway traveled by SARTA's existing bus system and by the proposed autonomous shuttles. If successful, SARTA will complete the road and curb assessment for its entire system. The proposed assessment will obtain data on road condition and repair needs, using cell phone based cameras mounted in vehicle windshields. This process will characterize roadways at a fraction of the cost of conventional systems, help to ensure that roadways are maintained as needed to support project implementation, and assist in trip planning by the Canton Smart Transit App.

Connected Vehicles System Testing. To aid in the setup and coordination of the proposed technologies and vehicles, and to ensure operability, OSU TRC will complete testing on the proposed systems and equipment prior to project demonstration. Specific items tested will include: autonomous vehicles (stoplight preemption, pedestrian alert and avoidance), DSRC testing (V2X radio, cellular, and modem communications, pedestrian alert tablet operation), Lyft vehicles (avoidance functionality, system operation), SARTA buses (system functionality), traffic signals (light controller testing), SARTA paratransit vehicles (pedestrian avoidance and alerts, system operation), and roadside units (verify communication with vehicle, traffic light, smartphone app, pedestrians, etc.).

2.0 Entity Description

2.1 Stark Area Regional Transit Authority

Celebrating its 20th anniversary this year, the Stark Area Regional Transit Authority (SARTA) has played a foundational role in bringing advanced, clean vehicle technology to the Ohio region. SARTA maintains an extensive transit network, providing over 2.8 million rides each year in and around Stark County, in northeastern Ohio. In operation since 1997, SARTA currently operates 34 fixed routes in Alliance, Akron, Canton, Cleveland, Hartville, Jackson Township, Louisville, Massillon, North Canton and Uniontown, with 79% of Stark County's population living within one-half mile of one of SARTA's fixed routes. To provide reliable service to as many as possible in Stark County, these fixed routes operate over 20 hours and over 7,500 miles each day, Monday through Saturday. SARTA also works as a regional transit partner and leader in advanced vehicle deployments, interfacing with green transit development occurring in Dublin, Smart City development in

Columbus, and other project team partners and regional transit authorities (see below for additional detail).

SARTA maintains a long term, forward looking commitment to deploying advanced transport vehicle systems and technologies, supporting improved access, reduced congestion, optimized transit system performance, and emissions reduction. SARTA has been highly successful in leveraging existing partnerships with regional universities, private businesses, and local governments to create a rapidly developing regional hub for advanced transit vehicles. SARTA's current fleet of 100 vehicles includes 40 converted low-emission compressed natural gas (CNG)-powered vehicles and four low-emission diesel-electric hybrid transit buses. SARTA is now taking delivery of, and will soon have in revenue service, 10 zero-emission fuel cell buses, and is actively pursuing additional deployments. These activities have been funded, to date, through a combination of federal grants ($8.9 million in federal grant funding in 2015, $4.0 million in federal grant funding through the FTA's Low-No program in 2016), agency funding, and partnerships with other local municipalities and corporations. In the near term, SARTA anticipates retaining only 25 diesel-powered transit buses, with the ultimate goal of a mostly zero-emissions fleet. The organization is also committed to deploying advanced tracking technologies and systems, including its existing PinPoint GPS system, and integration with regional smart cities.

In its desire to advance zero-emission technologies, SARTA recently joined into **partnership** with OSU CAR to form the Renewable Hydrogen and Fuel Cell Collaborative (RHFCC), funded in part by the U.S. Department of Transportation. The group's mission is to make Ohio and the US a global leader in the adoption of renewable hydrogen in transportation. The RHFCC is initiating programs in education and outreach, vehicle and infrastructure deployment, constructing a website, and developing regional and national partnerships to make hydrogen happen in the region. The collaborative is now reaching out to include the deployment of advanced technology vehicles, including through this proposal.

2.2 Program Management

The proposed project management and administrative team carries deep experience in federal grant administration and successful project management and execution. The project manager (PM), with strong technical support from the OSU-CAR Autonomous Vehicle group in the form of a technical director (TD), who will serve as the ultimate project leader, and will engage the project manager, support staff, project partners, and subcontractors. With day-to-day support from the PM, he will ultimately oversee the project, from initial baseline data collection, vehicle procurement, and facility design, through demonstration, outreach, and reporting. The project team will follow a standard and proven approach to vehicle and equipment deployment and demonstration that has been consistently and effectively deployed by SARTA and the project team on several prior grant-funded vehicle demonstration projects. The PM will closely coordinate internally with technical, deployment, and subcontractor leads through frequent meetings, calls, and email communications, to proactively identify and address technical and other issues and concerns that could otherwise interfere with project progress.

SARTA's experienced grants administration staff will maintain hands-on involvement with all administrative tasks, including the kickoff meeting, regular reporting, coordination of weekly internal meetings, and, with assistance from the PM, preparation, review, and delivery of required deliverables to DOT. Data systems deployment and integration will be completed by Teradata, under the oversight of the PM and SARTA, while traffic signal upgrades will be completed by the City of Canton. The Canton Transit App will also be developed under the oversight of the PM and SARTA by DigitalBuckeye. Finally, the proposed vehicle based ridesharing system will be deployed by Lyft, in coordination with SARTA and the PM.

2.3 Program Funding Management

Effective project funding management will include securing of match dollars, along with ongoing management of all project related funds. Briefly, upon initiation of the grant contract, SARTA's project administration team, under the oversight of the PM, TD and PD, will reach out to project partners to complete the contracting process, and to secure all applicable match funding. In-kind match commitments from subcontractors will also be codified (at levels indicated in this proposal) during the contracting process. Once subcontracting is complete and match funding is secured, SARTA's project administration team will work closely with DOT to manage budgets, tracking technical progress against critical path objectives and project spending on an ongoing basis. SARTA will report progress to DOT on a monthly or quarterly basis as requested by DOT, and will immediately notify DOT if a potential substantial cost or other budgetary deviation is identified. The project administration team will actively participate in scheduled conference calls and meetings with DOT staff to help ensure budget and schedule performance, and to provide a forum for discussing and troubleshooting critical issues.

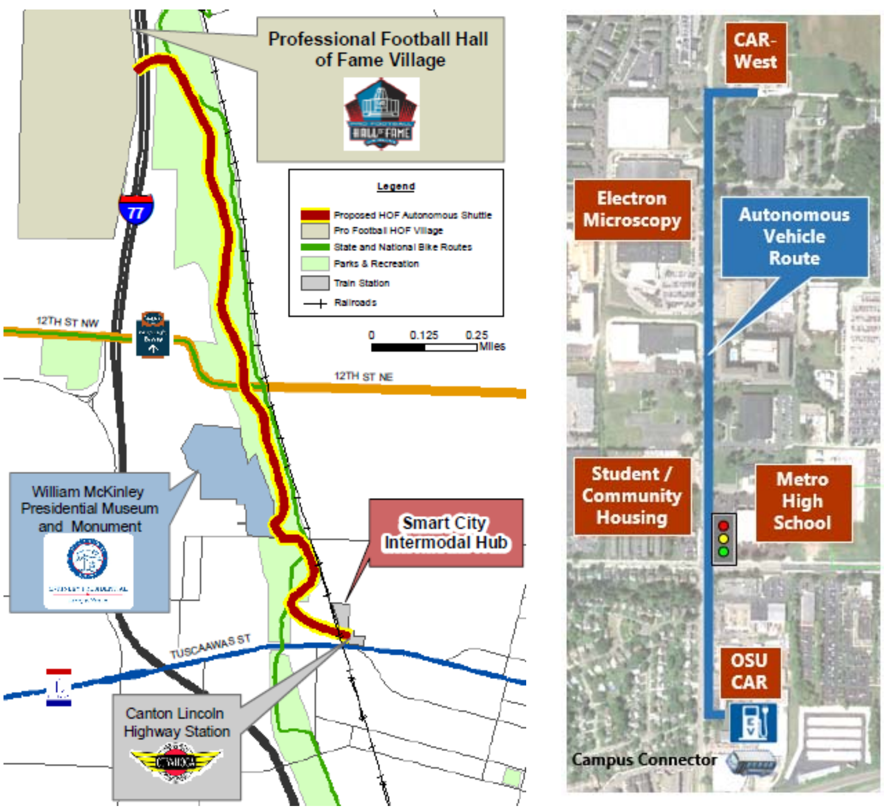

Figure 3: Autonomous Shuttle Loop: Hall of Fame Express (left) and OSU Research Laboratory Route (right).

3.0 Geographic Area/Jurisdiction

The project will be deployed across SARTA's service area—with a focus on the City of Canton and rural areas—and at the OSU campus in Columbus, Ohio. As shown in Figure 1 above, the proposed Lyft ridesharing vehicles will be deployed to connect the Canton Airport, downtown Canton, the Hall of Fame Village, underprivileged and other areas in Canton, and rural areas of

Stark County. The proposed bus upgrades will be deployed on existing buses serving SARTA's service area, including Canton's downtown corridor, supporting linkage from commuter and disadvantaged areas to industrial and commercial employment opportunity areas. The proposed AVs will be deployed along a dedicated autonomous vehicle route in Canton, with a single vehicle deployed at the OSU campus, as shown in Figure 3. The Canton route will provide a direct connection between the updated Football Hall of Fame campus and remote parking in downtown Canton. Ultimately, after the demonstration period, SARTA plans to add other stops at several of Canton's other main attractions, including the Akron-Canton Airport, the Belden Village Commercial Area, Kent State University, and Stark State College, while also providing access to Canton's downtown core area. Additionally, in the future, OSU plans to extend their AV route to connect to the main campus. Thus, the proposed routes will ultimately be optimized to provide service to critical points of interest and use, while also reducing Hall of Fame and OSU traffic and congestion. The Canton route will follow Park Drive, along an existing greenway. The vehicles will be routed along shared lanes along the proposed route, with pre-programmed stops. The AVs will be set up to be a part of the attraction of the Village with on-board entertainment that is coordinated with the Hall of Fame. When operational, shuttle buses will arrive every 10 minutes along the Hall of Fame Express Loop. At the OSU campus—one of the largest and most dispersed university campuses in the country, with over 100,000 students, faculty and staff—the proposed autonomous vehicle will connect main campus and research laboratories on the west campus with the potential of over 1000 riders a day. The estimated AV path in this application will be approximately 1.0 mile on a single-lane (in each direction) public road with moderate to heavy vehicle traffic (Figure 3). The OSU AV shuttle will operate every 10 minutes to move students, staff, and residents among research facilities, labs, classrooms, and residential areas daily.

4.0 Challenges and Alignment with Initiative

4.1 Real-world Issues and Challenges

SARTA's primary service area includes the cities of Canton, North Canton, Massillon, and Alliance, with extended service to Louisville, Hartville, and Cleveland. Despite a rich history that includes the early development of professional football and development of many classic American-manufactured product lines, the cities in SARTA's service area face several critical challenges. Sluggish economic development has been a central and long-lasting challenge for the county. While Canton in particular is making meaningful progress toward recovery from a decades-long urban decline (1960s through the 1990s), the City and surrounding areas have still struggled to hold up what is left of their once-vital manufacturing base. For example, leading vacuum maker Hoover recently announced closure of its last remaining facility in North Canton, representing the final step in the company's withdrawal from its birthplace, where the upright vacuum cleaner was first manufactured. Other key challenges largely relate to the long-term loss of industry and resulting changes in population dynamics and city infrastructure. Population in the City proper peaked in the 1950s at approximately 117,000, but has declined by 2% to 15% in each decade since that time to its current level of 72,000. This population decline has resulted in several unique challenges, including excess but declining infrastructure, low road capacities, and urban center decay, including loss of retail enterprises. The county and its cities have also faced planning challenges while trying to support economic development, including growth of urban sprawl, and the razing of many historic structures and closing of services.

Against this backdrop, the Pro Football Hall of Fame Village Expansion project (HOF Expansion) is expected to draw more than 8,200 visitors per day, on average, to Stark County and to Canton specifically. The HOF Expansion will redevelop the existing Hall of Fame campus into a first-ever *sports and entertainment smart city*, in a nearly $600 million development that promises to drive over $15 billion in much-needed economic development in the next 25 years.

As the agency tasked with providing public transit support to the region, SARTA is charged with providing reliable, equitable, and safe transit to and from the proposed campus, not only for the tourists, but also for the thousands that will work at the HOF Village. The HOF Expansion is expected to roughly triple the number of visitors to the site to 10,000 daily (including workers), but, due to space constraints, only 3,500 parking spots will be located on site. In addition, the HOF Village is located in a densely packed urban area, and congestion from thousands of additional vehicles would create unacceptable levels of congestion. Additional remote parking will be provided in Canton's downtown area, near retail shops entertainment and accommodations. SARTA, as the region's transit authority, will support the transit needs of remote-parking users and the community at large. The project will provide for increased transit needs of the HOF Expansion, with high-profile exposure of new and advanced autonomous vehicle technology, cloud-based ridesharing and transit services, advanced data management and analytics, congestion management, and enhanced safety systems, supporting modernization of Canton's transportation infrastructure.

The project will also help SARTA to test and implement new crash avoidance and bus / pedestrian and bus / vehicle safety technologies. SARTA will deploy these technologies in all proposed vehicles as shown in Table 1, starting with 10 percent of SARTA's buses, and eventually extending to the entire fleet. Bus-on-vehicle or bus-on-pedestrian accidents can easily lead to fatalities; the project will support testing of new warning systems, communication, and avoidance technologies that, if successful, will be deployed by SARTA on its conventional bus fleet, and its paratransit vans. Thus, the project will support a critical need for enhanced safety, reducing the number of potential parking area accidents and increasing pedestrian avoidance, while also serving as a testbed for future expanded crash avoidance technology deployments. RoadBotics will also analyze road conditions along 150 miles of project roadways, including the autonomous vehicle routes and many of SARTA's service area routes.

The proposed OSU route will be located in one of the most underserved areas of campus. Presently, large numbers of students travel this route, which connects classes, research laboratories, residential and parking areas. Parking in the area is especially impacted with limited availability and vigilant patrol with stiff fines, in spite of exceptionally high demand. OSU will deploy the autonomous shuttle in this area at reduced speeds (25 mph max) to help navigate high levels of congestion, parking pressure, and traffic congestion in these areas of campus.

4.2 Alignment with Initiative Goals

As shown in the table below, the project will strongly align with goals of this DOT initiative.

Initiative Goals	Project Element(s) Satisfying Initiative Goal
Multimodal Integrated Corridor Management (ICM)	(1) Create a smart data ecosystem where real time data, data from social services departments, and infrastructure assessment data will be collected and analyzed for multimodal transit. (2) Data analytics will identify effective ways to operate the

Initiative Goals	Project Element(s) Satisfying Initiative Goal
	multimodal system efficiently. (3) App will allow users to access the smart data ecosystem and analytics to assess most efficient transit solutions for economic, environmental, safety and access benefits. (4) Deploy new multimodal transit options (autonomous shuttle buses, Lyft vehicles)
Installation of Connected Vehicle Technologies at Intersections and Pedestrian Crossing Locations	(1) V2C, V2I, V2V, V2P communications for buses, Lyft vehicles, paratransit, and autonomous vehicles. (2) Pedestrians with DSRC units for pedestrian avoidance. (3) Smart traffic signals. (4) Smart paint and smart sensors/canes for vehicle guidance, pedestrian avoidance, and assistance for visually impaired. (5) Vehicles and 20 smart traffic signals communicate with cloud data environment.
Unified Fare Collection and Payment System Across Transportation Modes and Jurisdictions	(1) App will allow single payment for rides combining Lyft, the AV and SARTA. (2) Coordinates social service assistance programs for fare assistance for the disadvantaged.
Freight Community System	Smart data ecosystem, infrastructure assessment, and smart infrastructure provide the framework for future integration with logistics and the freight community.
Technologies to Support Connected Communities	(1) App will support rides across different jurisdictions and modes. (2) Coordination with various social services programs to provide the lowest cost for a ride to a particular individual. (3) Use appropriately outfitted vehicles to accommodate all needs. (4) Incentives to encourage the best (from a community perspective) possible ride.
Infrastructure Maintenance, Monitoring, and Condition Assessment	(1) RoadBotics makes visual assessments of conditions and prioritizes maintenance work. (2) Include infrastructure information in smart data ecosystem to assist in trip planning and determine maintenance priorities.
Rural Technology Deployments	App and Canton Smart Mobility Plan will include rural areas surrounding Canton; allows rural users to access Canton services and employment, but also allows rural users to shop and use entertainment options in the community.

Table 2. Project Alignment with Initiative Goals.

5.0 Transportation Systems and Services

The project will implement a variety of transportation systems and services, including data collection, management, and advanced analytics to help meet the proposed goals and implement SARTA's vision for advanced transportation and congestion management. Data analytics will be foundational to project operation, translating both long-term and real-time transit and user trends into usable information that will help gauge transit system efficiency, congestion points, and limited or underused service points, while supporting a transit user interface—the Canton App—and providing a framework for understanding the total picture of existing transit mobility (from cell phone data) and for transit system operational improvements.

The project will include **data collection** efforts that will target key transit information sources within SARTA's network of transit vehicles, while also interfacing with data available from the City of Canton, OSU, and privately available data such as cell-phone-based location and trip data. SARTA currently collects location data for all of its existing buses and transit vehicles. SARTA will also deploy similar vehicle tracking systems on each of the three proposed shuttle buses that it will operate under the project, with selected Lyft ridesharing van drivers, and with the upgraded SARTA buses using Lear technologies including DSRC radios for communication between vehicles, roadside units, and appropriately equipped riders, and cellular communication between vehicles and the data management system (see below). The proposed system will also collect and provide feedback using on-the-ground data from 15 sources including traffic signals, data collected based on the interface with smart paint, pedestrian tracking data including from smart canes, and (in the future) smart vehicle tracking data, and cell-phone location and trip data. Initially, Teradata will analyze the data under four use cases to assist the design and development of the Canton Smart Mobility Plan. All data will be routed to the proposed integrated smart data ecosystem and analytics system (Figure 4).

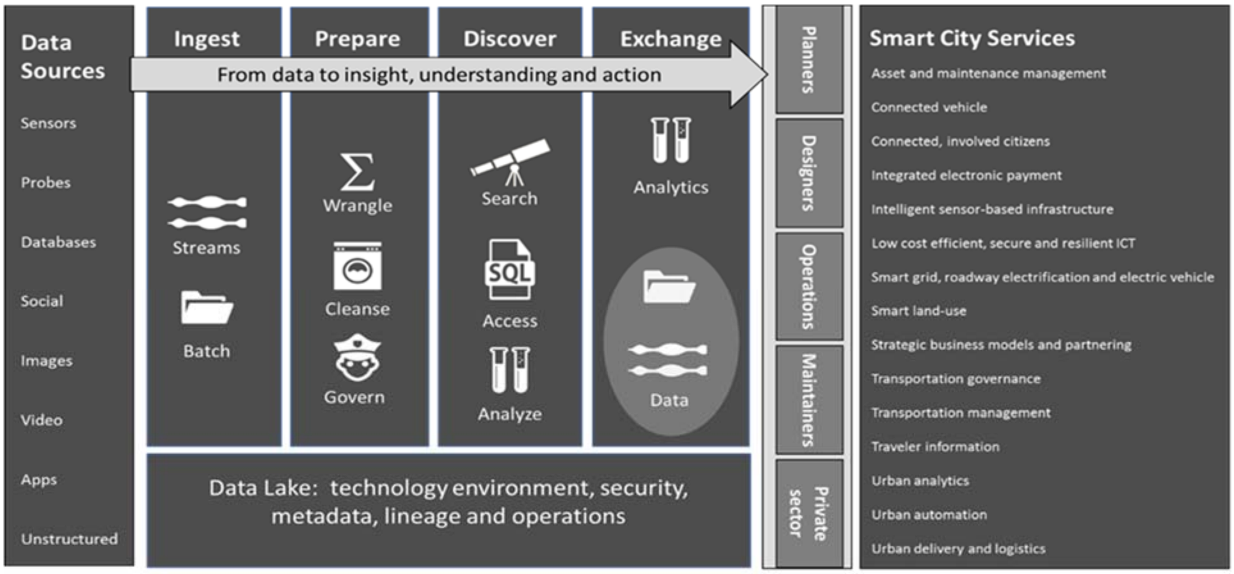

Figure 4. Teradata Data Environment and Analytics Configuration.

Led by Teradata, the project will implement a robust approach to **analytics** that will focus on harmonization across the transportation modes included in the project. Specifically, the system will provide: 1) a unified picture of safety, 2) increased efficiency in meeting transportation needs, and 3) enhanced transit-user experience. Teradata's system will capture data and process it through a Smart Data Exchange (a data analytics ecosystem) to:

- Enable exchange of data among Canton and various (private- and public-sector) data providers to support data sharing and development of rich applications, using a total of 15 data sources encompassing vehicle location, ridership, connected vehicle messaging, the mobile app, city sources, reference data, and third-party-provided cell phone location data.
- Support data analysis that will target development of improved understanding transit system performance, integration across history, and/or better understanding of the interplay between the different actors/sectors in the city. These will culminate in 1) a dashboard summarizing Canton transportation services and 2) accessibility analytics for the Canton area including multimodal transit in rural, urban, and disadvantaged sectors.
- Facilitate growth of an extensible system for exchange / analysis of data, as Canton's smart transit infrastructure grows and evolves beyond the grant period.
- Support data / analytics system replication by other transit authorities by providing an initial demonstration of the Smart Data Exchange system.

SARTA will implement the analytics system in four phases, two during the project period, and two separate phases following completion of the project. Phase 1 will include initial data collection from (1) SARTA's system to summarize transit system operations and movement; (2) commercially available cell phone locational data to track individual trips and overall traffic flow / congestion points; and (3) related transportation context data such as connected vehicle sensors/messaging, city sources, reference data, etc., as smart system elements are installed throughout the city. During this phase, 200 rural residents, 200 typical commuters, and 200 residents in underprivileged Canton communities will be recruited, as well as 400 daily tourists, for participation in the initial roll out of Canton's Smart Mobility Plan.

The data environment (see Figure 4) will capture, then query and analyze incoming data using intelligence/visualization and advanced analytics to understand how people navigate around Canton and surrounding areas, and congestion points, under existing conditions. The project team, led by Teradata, will then develop initial performance indicators that will target transit system optimization, congestion management, service to underserved and disadvantaged users, enhanced safety, and transportation customer experience. The project team will address performance indicators through adjustment of specific transit system operational procedures and parameters. Based on this analysis, the project team will design the initial smart mobility plan for Canton.

After Phase 1 analysis is complete, SARTA will implement the proposed operational procedures and parameters and evaluate performance for three months. The project team will continue to collect operational and traffic data during this period, and will assess the extent to which the updated operational procedures and parameters benefitted each performance indicator. Phase 2 will include an updated analysis, similar to that completed for Phase 1 but incorporating evaluation period data, and data collected from the use of the Canton Smart Transit App to develop a revised set of performance indicators and transit system operational procedure and parameter adjustments. The resulting metrics will be deployed during the 18-month demonstration period in a dashboard that summarizes transportation modes across regions, to support SARTA operational updates. In Phase 2, 400 rural users, 400 typical commuters, and 400 residents in underprivileged areas along with 4000 daily tourists will recruited (equivalent to 6% of Canton's population) to participate in the Smart Mobility Plan. In Phase 3, SARTA will further revise the Smart Mobility Plan for the region to prepare for expanding the number of people involved to about 15% of the city's population, as well as the number of transit options available. In addition, the freight community will be included in Phase 3 which will be implemented following completion of the project period, and will include a third round of analytics, building on data collected during Phase 2, with performance indicators and operational procedures and parameters to be deployed across SARTA's entire fleet. During this time, Teradata's smart data exchange will be able to grow and adapt to additional data sources and users, based on its accepted, scalable architecture and its built-in support for multiple business / transit intelligence tools. Thus, the analytics system will be highly scalable to support future expansion. Finally, in Phase 4, to be completed about 2 years after project completion, the Smart Mobility Plan will be extended over the entire SARTA district.

6.0 Deployment Plan

6.1 Deployment Plan

The project's deployment plan has been carefully developed to support an exceptionally high likelihood of success, including sustained use of the proposed equipment well beyond the 18-month demonstration period. The project will be completed in the following tasks:

Task 1. Project Management and Administration. SARTA, in coordination with the Project Director (PD) and with support from CALSTART, will complete all contracting, oversight, coordination, day to day management activities, and other actions discussed in Sections 2.2 (Program Management) and 15.1 (Staffing Description).

Task 2. Development, Procurement, and Equipment Installation. This task will include all activities needed to complete project development, procurement, and vehicle and equipment installation. Under ***Task 2.1, Development and Planning***, SARTA and the PD will work with the project team to gather needed specifications, complete engineering for the proposed fuel cell, finalize the detailed routes GPS positioning, and stoplight preemption for the proposed autonomous vehicles, and coordinate with all subcontractors and project partners prior to procurement of the equipment and services proposed under the project. SARTA and the PD will complete all procurement activities under ***Task 2.2, Vehicle and Equipment Procurement***, including four autonomous shuttles; connectivity and safety equipment for 10 existing SARTA buses, five existing SARTA paratransit vehicles, and 10 Lyft passenger vans; acquisition of the fuel cell from the Navy (including testing to ensure functionality); equipment for 20 connected traffic signals; all pedestrian connectivity equipment including smart canes; the smart paint; and initial coordination with Teradata, Digital Buckeye, and RoadBotics. Lyft will also initiate its process for identifying qualified drivers during this period. ***Task 2.3, Vehicle Delivery*** will include delivery of the four EasyMile autonomous vehicles: three to SARTA and one to the OSU campus. ***Task 2.4, Equipment and Analytics Delivery and Installation*** will include delivery and installation of all remaining equipment and other items (i.e., smart paint/sensors) procured under Task 2.2. This task will also include setup and trial of the proposed analytics platform and development of the Canton App. During this period, OSU TRC will also deploy DSRC testing to validate V2X radio, cellular, modem, and tablet connections, as well as all traffic lights, pedestrian avoidance, vehicle avoidance, and stoplight preemption functionality.

Task 3, Implementation and Demonstration. This task will include project implementation, operation during the demonstration period, analysis, and reporting. During ***Task 3.1, Phase 1 Analytics***, SARTA and Teradata will complete the Phase 1 Analytics discussed in Section 5.0 (Transportation Systems and Services), and the project team will initiate select repairs identified by RoadBotics. The proposed vehicles and systems will be operated in a testing mode, to test and tune applicable operation parameters. ***Task 3.2, Project Demonstration and Phase 2 Analytics*** will include an 18-month demonstration period for all vehicles, equipment, and systems, including the Phase 2 Analytics discussed in Section 5.0. This task will also include monitoring and data collection to support analysis and reporting. All vehicles and equipment will be operated for the duration of the demonstration period. Assuming that the project is successful, the project team will continue to operate the proposed vehicles and equipment through their ten-year service life. Under ***Task 3.3, Outreach, Analysis, and Reporting***, CALSTART will complete outreach activities and CALSTART, SARTA, and the PD will complete data analysis based on data collected under Task 3.2, and reporting to DOT.

6.2 Operation and Maintenance Plan

The project will deploy, operate, and maintain a total of four new autonomous vehicles and 10 Lyft ridesharing vans, along with crash avoidance, pedestrian avoidance, and connected vehicle equipment on 10 existing SARTA buses and five existing SARTA paratransit vehicles. The project will also deploy, operate, and maintain proposed infrastructure, including the proposed fuel cell, 20 smart traffic lights, and smart paint pavement markings, 4 smart canes, and 20 portable DSRC units to be provided to select riders. The project will deploy an operations and maintenance plan for the project, which will identify standard operation and maintenance procedures for all proposed equipment. Briefly, under that plan, SARTA will operate all SARTA vehicles on a daily basis, while SARTA's maintenance team will maintain all existing and proposed SARTA vehicles in accordance with their prescribed vehicle maintenance requirements. Additionally, SARTA will inspect all on-vehicle pedestrian and crash avoidance equipment at least weekly to confirm its operation. EasyMile will provide training to SARTA maintenance to support maintenance of the proposed autonomous shuttles, set up maintenance schedules based on anticipated use, and also provide a warranty covering equipment malfunction during the project period. The OSU campus area bus system will operate a similar maintenance plan on the AV shuttle located on its campus.

Lyft vehicles will be operated and maintained by Lyft's owner-operators, consistent with Lyft's business model. The proposed vehicle-mounted smart infrastructure and telecommunications equipment will be operated and maintained by SARTA, as will the proposed fuel cell power supply system. The City will operate and maintain smart / connected traffic lights, in coordination with SARTA. The project team will deploy smart paint once during the project period; it will not require operation or maintenance within the project term. Individual users will operate and maintain (charge or replace batteries as needed) the proposed connected pedestrian / smart cane systems. SARTA will coordinate with the City to complete roadway maintenance as needed, as identified by the RoadBotics assessment.

7.0 Regulatory, Legislative, or Institutional Challenges

7.1 Regulatory Challenges

Existing regulatory challenges relevant to the project are limited. Ohio does not presently maintain restrictions or guidance on the deployment of unmanned vehicles, as is the case in some states (although see Section 7.2, Legislative Challenges, for additional information). Based on a recent review completed by both SARTA and the City of Canton, City and SARTA policies are both considered favorable to deployment of the project, which is strongly in line with the goals and objectives proposed under SARTA's current 5-year plan. City policies and planning are currently under revision (under a separate initiative). If the project is awarded funding, the City plans to fully evaluate and update City policies to ensure compatibility with the proposed project, as well as future autonomous vehicle deployments. OSU currently maintains numerous policies that provide strong support for demonstration and use of advanced vehicle technologies on campus. A preliminary review of OSU policies indicated that the project is likely to be wholly compatible with OSU's existing policies regarding autonomous vehicles and advanced vehicle technology demonstrations. If unanticipated conflicts or deficiencies in policy are identified for SARTA, the City, or OSU, the entities are committed to deploying the project, and will work quickly to alleviate such issues.

7.2 Legislative Challenges

SARTA does not presently foresee any significant legislative challenges regarding deployment of the proposed smart infrastructure or autonomous vehicles. Early in 2017, legislation that would have required presence of a person with a valid commercial driver's license, able to take control of the autonomous vehicle at any time, was being considered in the Ohio legislature. However, as of the time of submission of this application, these bills had been discontinued. Presently, SARTA is working with ODOT and state legislators (to the extent warranted) to identify Canton and Columbus as autonomous vehicle demonstration zones, thereby ensuring the project team's ability to deploy the proposed vehicles. Based on current status, SARTA anticipates that this collaboration will be successful. Even in the unlikely event that Canton and Columbus cannot be identified as a dedicated demonstration zone, SARTA will continue to work with ODOT, state legislature, and the Columbus Smart City team to find a workable solution to deploy the project. Therefore, legislative challenges are expected to be avoidable.

7.3 Institutional Challenges

Institutional challenges for the project would also be limited, based on a preliminary review completed for SARTA, the City of Canton, and OSU. The project would align very closely with SARTA's existing strategic direction surrounding deployment of advanced and low-emission vehicles, with the City of Canton's charge to support economic development, safety, and environmental sustainability, and with OSU's commitment to safety, sustainability, and advanced transportation development and demonstration. The project would not include elements that would conflict with or interfere with institutional governance or management for SARTA, the City of Canton, or OSU.

While the project would involve participation by a university, the proposed equipment will be deployed in a dedicated area that would minimize institutional challenges at OSU. The proposed testing at TRC will also serve to minimize institutional risks at OSU and Canton by ensuring that the autonomous vehicles and smart technologies meet university and state standards and are working correctly before they are implemented. In addition, OSU-CAR and, in particular, the autonomous vehicle group at OSU-CAR, which is world renowned for its work in intelligent vehicles, will oversee the implementation of the AV shuttles and smart technologies, helping to ensure project success. Finally, the AV will be integrated into the Campus Area Bus System, which is very open to alternative fuels and new vehicle types, as evidenced by its operation of a fuel cell bus on campus and the transition of its fleet to CNG. OSU does not anticipate other institutional challenges.

7.4 Other Challenges to Deployment

Other potential challenges include interfacing with existing infrastructure, some of which is founded on older standards or older infrastructure, and which may not be fully compatible with the proposed system. Based on a preliminary review of the proposed routes and available infrastructure serving those routes, potential challenges would be limited to interface with stoplight preemption systems. A total of 20 stoplights will require systems upgrades in order to interface with the proposed vehicles. All needed updates will be completed in support of the project, prior to deployment of the autonomous vehicles, thereby alleviating this challenge. Technical challenges specific to vehicle operation would also be limited. Recent demonstrations and deployment completed by EasyMile highlight straightforward and low-maintenance operation, with limited downtime beyond charging and routine maintenance. However, even in the event of an unexpected down vehicle, SARTA would deploy its third, backup vehicle, in order to maintain service while repairs are being made. Therefore, operation period technical challenges are expected to be limited.

8.0 Quantifiable System Performance Improvements

The project will support the following categories of quantifiable system performance improvements:

- **Safety: Pedestrian Avoidance.** The project will implement pedestrian avoidance measures for autonomous vehicles (alert and automatic braking), Lyft vehicles (pedestrian alert), SARTA buses (pedestrian alert) and existing ADA-equipped SARTA vehicles (pedestrian alert). Smart paint will help guide the visually impaired, while smart canes for the visually impaired will help track their location relative to connected vehicles. SARTA will quantify improvements to pedestrian avoidance by comparing the rate of vehicle-on-pedestrian incidents (alerts, close calls, and actual collisions) per year under existing conditions to the rate of incidents during project demonstration. In addition, the data collection system employed will collect safety related information, both in terms of events that occur, and in term of near misses when the avoidance systems are activated.
- **Safety: Reduced Traffic Related Crashes.** The project will implement robust vehicle based crash avoidance systems (see vehicle description) and stoplight preemption for autonomous vehicles. Connected buses will include signal coordination. Smart paint will help to guide autonomous vehicles. SARTA will quantify improvements by comparing the rate of vehicle-on-vehicle incidents per year for connected (i.e., project) vehicles versus non-connected vehicles in its service during the demonstration period.
- **Congestion.** The project will directly reduce congestion by supporting ridesharing, providing an alternative to on-site parking at the Hall of Fame Village, reducing traffic and congestion in the Hall of Fame Village area, and supporting transit use across SARTA's system. SARTA will quantify congestion reduction by tracking increased ridership associated with the project, as well as by comparing the severity of existing congestion (identified during the Phase 1 data analytics; Section 5.0) to that identified during project operation (i.e., Phase 2 data analytics). Congestion will be a measured quantity with other information collected in the smart data environment.
- **Costs.** SARTA's proposed ridesharing system will reduce direct and environmental transit costs for users. The Canton App will also enable reduced costs by identifying lowest-cost routes for users. SARTA will quantify cost reduction for its users by tracking transit costs for individual rides during the demonstration period and comparing those to ride costs under existing conditions without the benefit of the project or the Canton App. This comparison will be supported by the analytics system discussed in Section 5.0.
- **Improved Access to Transportation, Services and Employment.** The project will provide new service to Hall of Fame Village visitors and will also provide additional, lower-cost services to rural and disadvantaged areas through the proposed ridesharing program, and enhanced service using existing buses and paratransit vehicles, connecting riders to commercial and industrial employment areas. SARTA will quantify improved access to transportation services and jobs by identifying increases in ridership from disadvantaged and rural areas, and increases in ridership to the Hall of Fame Village, in comparison to existing conditions.

- **Optimization of System Efficiency.** A system efficiency will be defined in terms of measurable quantities such as cost, ride time, congestion reduction and access to services. The project will optimize system efficiency by deploying autonomous vehicles and the proposed ridesharing program, and also by updating key transit operations and parameters through the proposed data collection and analytics system, including via the Canton Smart Transit App. The project will track improvements in system efficiency by comparing existing data to demonstration-period traffic and transit data on traffic congestion, ridership, transit system scheduling improvements, wait time reduction, and cost optimization.
- **Environmental Benefits.** The project will provide significant emissions reductions by deploying zero-emission, battery-electric shuttle buses that will run on renewable energy, by expanding ridership in SARTA's fleet of zero emission buses, and by supporting system optimization and increased use of public transit and ridesharing. In addition, RNG will be used for CNG vehicles (with a negative carbon footprint), and the electricity used to charge battery electric and plug in hybrid vehicles will be derived from a fuel cell with waste heat reclamation and powered by RNG. SARTA will quantify these benefits by tracking the amount of renewable energy consumed by the shuttle buses, measuring reductions in energy consumption and carbon and pollutant emissions across SARTA's transit system, and tracking the number of riders using the proposed system, which can be directly related to reductions in the use of individual vehicles, and the resulting reductions in emissions.

9.0 Benefit Projections

The project will provide several categories of quantifiable benefits, as discussed in Section 8.0. In support of this application, SARTA has completed the following projections for anticipated benefits under the project.

- **Safety: Pedestrian Avoidance.** Under existing conditions, SARTA has recorded an average of approximately two vehicle-on-pedestrian fatalities per year in recent years. The project would deploy pedestrian avoidance measures on 19 vehicles in SARTA's fleet. SARTA anticipates a 25% to 50% reduction in vehicle-on-pedestrian incidents in vehicles utilizing pedestrian avoidance technology, in comparison to similar vehicles in SARTA's fleet that will not use the technology.
- **Safety: Reduced Traffic Related Crashes.** Under existing conditions, SARTA has recorded an average of 15.4 vehicle-on-vehicle incidents per year, resulting in insurance claims of up to $214,000 per incident. The project would deploy crash avoidance systems on the proposed autonomous vehicles and 10 SARTA buses. SARTA estimates a 25% to 40% reduction in vehicle-on-vehicle incidents per year for vehicles outfitted with crash avoidance technology, in comparison to similar vehicles not outfitted with the technology.
- **Congestion.** Congestion reduction will focus primarily on congestion surrounding the Hall of Fame Village, which is not yet operational. Therefore, benefits are quantified in comparison to anticipated conditions in the event that the project were not implemented. The autonomous shuttle will provide transit service to up to 2,100 Hall of Fame visitors per day, thereby reducing the number of vehicles in the vicinity of the Hall of Fame Village by approximately 800 per day. By offering incoming travelers the Smart Transit App, as well as increased convenience and reduced costs, it is estimated that half of the incoming tourists (or 4100 travelers per day) will use project services. Assuming just over 2 rides per hour, Lyft vehicles will serve up to 1,000 people per day, avoiding at least 200 daily individual vehicle trips. The

project will also provide an estimated 20% to 30% reduction in congestion within SARTA's transit system, based on Teradata's proposed system optimization.

- **Costs.** Under existing conditions, per-ride costs for rural users of SARTA's transit system average $36, while general system user per-ride costs average $21. The proposed ridesharing and Canton App systems would reduce these costs by an estimated 50% and 10%, respectively, resulting in average per-ride reductions of $18 and $17, respectively. This represents a significant potential cost savings to SARTA and its riders. In addition, environmental costs will be reduced to zero for the AVs and ZEV buses in use, and dramatically reduced for the plug in hybrid and CNG vehicles used for the program.
- **Improved Access to Transportation Services.** The project will provide new service to the Hall of Fame Village. SARTA estimates that approximately 30 to 50% of the 10,000 visitors per day to the Hall of Fame will rely on SARTA transportation systems for at least a portion of their transit needs. Therefore, SARTA estimates that the project will provide 4,100 new rides per day to transit users, along with approximately 1,000 trips per day for Lyft vehicles. In addition, Lyft will be providing rides in the community. Currently, access to employment is close to zero through rapid transit. The goal is to provide 30 trips per day from the disadvantaged population initially, and up to 60 rides per day by the end of the grant period.

10.0 Vision, Goals, and Objectives

10.1 Vision

The project team's vision for the project is to deploy the proposed integrated transit system and smart data ecosystem through a replicable and scalable system that can learn as it grows and be used as a model for both future SARTA deployments and for similar deployments in other cities. By operating the proposed vehicles and intelligent transportation systems, the project will demonstrate both on-road and dedicated autonomous vehicle operation, data-integrated ridesharing, and advanced safety features, along with the power of a cloud-based integrated data collection and analysis system with infrastructure monitoring. These deployments have been strategically designed to support future expanded deployment of these technologies both by SARTA and by other regional transit agencies and municipalities. If the project is successful, SARTA will expand this system to cover the region and also to cover freight and logistics, as well as the use of other modes of transportation such as bike sharing and car sharing. SARTA will also continue to build out its smart infrastructure by further deployment of vehicle avoidance, smart paint, pedestrian avoidance, and smart traffic signals, as outlined in SARTA's existing transit plans, however, these will be accelerated and expanded with implementation of the project. Such future deployments would help to further alleviate traffic congestion in key high-use locations in SARTA's service area, while supporting additional emissions reductions and operation cost savings in comparison to conventional vehicles and systems. The project will also provide a testing grounds for multiple advanced pedestrian detection and crash avoidance systems, which if successful, SARTA plans to deploy across its transit vehicle fleet and service territory. Finally, the proposed vehicle and technology deployments will fully and thoughtfully interface with SARTA's and the City's available assets and infrastructure, including SARTA's real-time bus tracking and scheduling systems.

SARTA, in its **organizational vision** for effective transit, seeks to provide safe, responsive, and effective transportation for all citizens within its service area, while also minimizing environmental footprint and supporting regional economic development. To that end, SARTA maintains a long-term, forward-looking commitment to deploying advanced, low- and zero-emission vehicles, and has been highly successful in leveraging existing partnerships with regional universities, private businesses, and local governments to create a regional hub for advanced fuel vehicles. SARTA's current fleet of 100 vehicles includes 40 converted low-emission CNG-powered vehicles and four low-emission diesel-electric hybrid transit buses. SARTA is now taking delivery of, and will soon have in revenue service, 10 zero-emission fuel cell buses. These activities have been funded, to date, through a combination of federal grants ($8.9 million in federal grant funding in 2015, $4.0 million in federal grant funding through the FTA's Low-No program in 2016), agency funding, and partnerships with other local municipalities and corporations. Growth in the fleet's low-emission vehicles represents SARTA's commitment to moving its entire fleet to low- and zero-emission vehicles through conversion and new vehicle acquisitions as existing diesel vehicles reach the end of their lifespans. In the near term, SARTA anticipates retaining only 25 diesel-powered transit buses, with the ultimate goal of a mostly zero-emissions fleet. The organization is also committed to deploying advanced tracking technologies and systems, including its existing PinPoint GPS system, and integration with regional smart cities. These efforts will strongly support SARTA's desire to reach the underserved and disadvantaged, and to connect those in need of jobs with employment opportunities through safe, reliable, and affordable transportation.

The proposed autonomous vehicles and supporting infrastructure will **strongly align with SARTA's organizational vision**. It will directly support SARTA's institutional goals and commitments surrounding development of a regional hub for advanced fuel vehicles. If selected for funding, this project would represent the first deployment of autonomous vehicles for public transit in the state of Ohio. As a result, the project would help to solidify SARTA's position as a regional leader in advanced transit vehicle deployment, while also demonstrating key benefits of the technology, including increased safety, reduced operational costs, zero-emissions operation, integration with existing control systems, and use of renewable energy. The project will also help SARTA to make incremental progress toward reaching its goal of retaining only 25 diesel-powered transit buses in the short term, both directly by deploying three new vehicles, and by demonstrating autonomous vehicle technologies that could be deployed in greater numbers in the future. Finally, the project will strongly support SARTA's vision surrounding safety, wherein SARTA seeks to test relevant pedestrian detection and crash avoidance technologies. Ultimately, SARTA seeks to deploy these technologies on all of its buses; the project will serve as a means to test and demonstrate multiple technologies under actual operational conditions at SARTA. These steps will help SARTA to make transportation affordable and increase transit access to employment opportunities for all.

10.2 Goals

Project goals will closely align with the advanced transportation and congestion management technologies deployment initiative, as applicable to the project, and will include: 1) Provide a complete, integrated transit solution to SARTA transit users, including disadvantaged and rural riders, commuters, and tourists including tourists visiting the Hall of Fame Village; 2) Build a smart data ecosystem with an initial 15 data sources, which will become the foundation for the Canton Smart Mobility Plan; 3) Optimize transit planning and payment through the use of advanced tracking and interconnected vehicle systems; 4) Reduce traffic congestion and vehicle emissions in Canton and the OSU campus; 5) Reduce operation costs and improve return on investment through the use of autonomous vehicles; 6) Provide environmentally friendly transit including reduced emissions and use of renewable energy; 7) Measure and improve operational performance of SARTA's and the City of Canton's transportation networks; 8) Increase safety by reducing the number and severity of traffic crashes; 9) Demonstrate reduced delays, improved system performance, and reduced traffic congestion through the use of ridesharing vehicles, autonomous vehicles, and interconnected vehicle systems deployment; 10) Demonstrate technologies and systems that would be reproducible at other sites, including ridesharing vehicles, autonomous vehicles, interconnected vehicle systems, advanced pedestrian detection and crash avoidance, electric vehicles, and renewable powered vehicles; 11) Assist underserved and disadvantaged communities in SARTA's service area; 12) Coordinate with the AV deployment in the Columbus Smart Cities program as well as their app development and use; 13) Support information sharing; 14) Integrate advanced technologies into transportation system management and operations; and 15) Develop an infrastructure monitoring system that will eventually encompass the entire SARTA service territory (RoadBotics)

10.3 Objectives

Project goals will be achieved through the following objectives: 1) Deploy 10 Lyft ridesharing vehicles to connect rural areas and provide transit opportunities among key Canton area destinations; 2) Deploy three zero-emission, battery electric vehicles (connecting the Pro Football HOF to remote parking in Canton) fueled with renewable electricity, that will reduce on-road air emissions by 100% in comparison to conventional vehicles, while enabling very low well-to-wheels emissions, plus one additional zero emission vehicle at the OSU campus (connecting university facilities); 3) Install and operate connected vehicle hardware for four new autonomous shuttles, 10 SARTA buses, 10 Lyft passenger vans, and five SARTA paratransit vehicles; 4) Install a new cloud based data warehouse, and data collection, management, and analytical infrastructure and software with 4 use cases initially; 5) Develop and provide to users, free of charge, the Canton Smart Transit App, which will identify transit routes, costs, and support choice of environmentally friendly transit alternatives; 6) Deploy autonomous, driverless vehicles that will reduce driver labor costs by up to 70% for those vehicles; 7) Deploy multi-faceted, advanced pedestrian detection and crash avoidance technologies on 29 vehicles (four autonomous shuttles, five paratransits, ten SARTA buses and 10 Lyft ridesharing vans), to increase safety and to serve as demonstration for future deployments of these technologies; 8) Operate the proposed ridesharing vehicles and autonomous vehicles in lieu of installing additional parking space at the HOF, reducing traffic congestion at the HOF Village site; 9) Operate the proposed autonomous vehicles and ridesharing vehicles to reduce traffic congestion; 10) Install and operate a stationary, renewable natural gas based fuel cell to generate enough power to supply the proposed Canton area autonomous vehicles, and to support SARTA operations with negative carbon emissions and zero air pollutant (NOx, CO, particulates, etc.) emissions; 11) Upgrade stoplight preemption and interconnection of 20 traffic signals to enable interface with autonomous vehicles and other smart vehicles; 12) Share data / results with Columbus Smart Cities; 13) Operate infrastructure monitoring system to prioritize where maintenance is needed and to integrate this information into the travel system; 14) Develop a smart data ecosystem with 15 data sources which can be used for a variety of data analytics purposes but that will drive the development of a smart mobility plan for Canton; and 15)

Disseminate project results to support information sharing and promote use of advanced vehicles and advanced vehicle management systems in other region cities and communities.

10.4 Alignment of Goals, Objectives, and Activities with Identified Issues and Challenges

Issue/Challenge	Relevant Goals, Objectives, and Activities
Manage vehicle congestion in Canton and at OSU	G1, G2, G4, O1, O2, O3, O4, O8, O9
Increase transit efficiency and enhance ridership	G1, G2, G3, G7, G9, G14, O1, O2, O3, O4, O5
Interface with existing infrastructure	G2, G15, O2, O3, O4, O11
Provide economic benefit to areas served by the Project	G1, G3, G11, O1, O2, O3, O5, O15
Support reproducibility and future adoption of regional advanced transit vehicle deployments	G1, G2, G10, G12, G13, O1, O2, O4, O12, O13, O14, O15
Increase safety	G1, G8, O2, O3, O4, O7, O13
Reduce emissions and provide environmental benefit	G1, G6, O2, O4, O10
Increase access to underserved communities	G1, G7, G11, O4, O5
Reduce transit costs	G1, G2, G5, G7, O1, O2, O3, O4, O5, O6

11.0 Plan for Partnering

SARTA will continue to deeply leverage leading regional research institutions and organizations, smart cities including the Columbus Smart City, and private corporations and foundations, and Ohio state agencies to support partnership under the project. Collectively, these partners will implement the project as one facet of an overall collective goal to modernize and reinvigorate Ohio's Rust Belt cities, while developing a regional hub for the integration of advanced, clean transit systems. Project partners will include:

The Ohio State University Center for Automotive Research (CAR) is the pre-eminent research center in sustainable and safe mobility in the United States and an interdisciplinary research center in The Ohio State University's College of Engineering. CAR offers state-of-the-art facilities for students, faculty, research staff and industry partners. CAR offers advanced experimental facilities that include engine and vehicle dynamometers, vibration, noise and acoustics laboratories, intelligent and autonomous vehicle laboratories, engine fluid mechanics and combustion research facilities, and electric, hybrid-electric propulsion, and fuel cell research facilities. OSU is currently working with SARTA to deploy an AFCB at the OSU campus. OSU CAR has additionally won and managed many federally and state funded projects focusing on a large variety of alternative fueled vehicles and is particularly noted for its work in autonomous vehicles.

The Ohio State University
Center for Automotive Research

The Ohio State University Transportation Research Center Inc. (TRC) is the largest independent vehicle test facility and proving grounds in the U.S. The TRC specializes in testing, calibration, and engineering solutions and support for numerous categories of vehicles, including automated and autonomous vehicles. The organization also recently (January, 2017) announced allocation of $45 million in funding for the construction of a state of the art facility for the testing and validation of automated vehicles. In conjunction with this effort The Ohio State University (OSU) has pledged and additional $24 million to place faculty, staff and students at TRC.

TRC Transportation Research Center Inc.

Lyft Inc. (Lyft) is a San Francisco, California-based company whose business model centers on a ridesharing system designed to help people share rides with friends, coworkers, and fellow travelers who are going in the same direction, through private and social networks for ridesharing. Founded in 2007, the company operates in over 550 US cities, including Akron which is close to Canton. The company has rapidly developed as a nationwide pioneer in ridesharing, vehicle tracking and management, and mobile phone app based interface with riders. Lyft drivers applicable to the project will be private vehicle owner-operators who meet base driver and vehicle standards, including availability of vehicles able to carry at least five passengers.

CALSTART is a national strategic broker for the clean and smart transportation industry, dedicated to growth of a clean transportation industry that will create high quality economic opportunities, reduce GHG emissions, and support smart growth and infrastructure development. CalStart oversees and manages tens of millions of dollars in grant funds each year, and will provide administration support, outreach, and documentation of benefits/successes for the project.

City of Canton. Canton maintains extensive experience in effectively administering, and rapidly and successfully deploying federal grant programs, including homeowner support programs through the US Department of Housing and Urban Development (HUD), as well as community development block grant and emergency solutions grant programs. Canton maintains a wide array of existing public services and infrastructure, described throughout this proposal, which it will bring to support the project. During the planning and deployment phases of the project, the City will work closely with SARTA to help manage development and implementation of the project, while also coordinating internal resources and supporting outreach and collaboration with other project partners.

Pro Football Hall of Fame. The Pro Football Hall of Fame is the focal tourist attraction in the City. The organization is currently in the process of planning a major expansion which, as discussed elsewhere in this proposal, will deploy an amusement-park-like Hall of Fame Village focused on providing in-person and interactive experiences to incoming visitors on one centralized campus. Thus the Hall of Fame will require careful planning and integration with the proposed smart city system, relying on public and private transit opportunities as well as parking services to support its proposed use. Transportation will be a critical element for the Hall of Fame Village's employees and visitors, and will play into visitors' first experiences of the updated Hall of Fame campus.

Quasar Energy Group is a Cleveland, Ohio-based renewable energy and organics management firm specializing in the deployment of sustainable technology solutions in industrial, municipal, and agricultural applications. The company operates an anaerobic digester research facility in conjunction with the OSU Agricultural Technical Institute, and routinely designs, builds, and provides various levels of operational support to fourteen anaerobic digesters located in Ohio, Maine, Massachusetts, and New York.

Teradata is leading data analytics systems provider serving transportation and related industries. The company's transportation and logistics data modeling and management systems incorporate a data warehouse with analytics that target transportation optimization for various fleets, including transit, delivery, and distribution logistics systems. The company has successfully deployed optimization systems for major transit oriented companies including Air Canada, DHL Express, and BNSF Railway, Union Pacific Railroad, and Maersk, and is increasingly deploying its systems to support smart cities with smart mobility planning and implementation.

EasyMile is an advanced vehicle startup that specializes in providing software and hardware to power autonomous vehicles, along with custom tailored smart mobility solutions for the human transportation sector. Founded in 2014, the company is headquartered in Toulouse, France, and maintains offices in Denver, CO and Singapore. The company is privately held and growing, with a workforce of 70. Through its affiliation with French autonomous vehicle maker Ligier, the company's vehicles have provided over 1.5 million rides since the vehicles were first tested in 2008.

Lear Corporation is a Fortune 500 corporation that designs, engineers, and manufacturers a wide variety of automotive electrical, seating, and, increasingly, vehicle communication technology and equipment. The company's connected vehicle systems include advanced vehicle-to-vehicle and vehicle-to-infrastructure on-board and roadside units, as well as associated software and cybersecurity equipment and programming. To date, Lear has deployed road-side equipment in more than 20 cities and other locations across the US and globally, supporting vehicle connectivity and analytics. Lear's systems provide a secure connection to the cloud and to transportation data management and analytical systems, providing a means for improved safety, traffic control, and mobility services and applications.

DigitalBuckeye is a mobile application (app), web, virtual reality, and data developer that specializes in development of tools to simplify user interface with complex data systems. Headquartered local to the project team in Columbus, Ohio, the company develops easy-to-use interfaces and custom reporting, including mobile apps.

Intelligent Material Solutions (IMS) develops and commercializes advanced materials designed to enhance detection and sensory abilities across regions of the electromagnetic spectrum, particularly in the near to mid infrared wavelengths. The company is a leading developer of smart paint technologies, which use advanced materials painted onto roadways to allow special sensors to precisely determine location, identify hazards, and precisely communicate with connected vehicles and pedestrians.

RoadBotics deploys an advanced road sensing and status tracking system that identifies road conditions rapidly and easily, informed by advanced data and analytics. Based on technology developed by Carnegie Mellon University (CMU), the company specializes in road monitoring systems for governments and transit authorities, supporting interface with smart road and vehicle technologies.

12.0 Leverage and Optimization

The project will leverage existing/prior advanced transportation technology investments made by SARTA. In 2015 and 2016, SARTA contributed over $3 million in local funds to match $12.9

million in federal grant funding. These ongoing projects include procurement and demonstration of 10 zero-emission fuel cell buses, which will be retrofitted under the project with advanced telematics, as described previously. SARTA's transit development and capital investment planning proposes additional capital investments based on SARTA and state funding during the next five years. These funds will be used to continue to progress toward SARTA's goal of maintaining only 25 active diesel-fueled buses. The project will help SARTA to optimize use of these funds by guiding advanced vehicle and technology deployment in the coming years. These additional funds will also be used to expand the project identified under this application, to deploy advanced safety features, data management, and analytics/optimization for all of SARTA's vehicles, while also supporting future deployments of autonomous vehicles on select routes. SARTA will also leverage funding from state agencies such as OEPA and ODOT, foundations, private corporations, and from the sale of collected data.

The project will also strongly benefit from existing / prior investments in advanced transportation technologies and systems made through OSU. Drawing on 25 years of combined funding from industrial consortia memberships, direct corporate sponsorship, and state and federal funding, the project will directly benefit from OSU CAR's leadership in advanced vehicle design, engineering, and deployment. The project will also leverage local and state transportation related funding through the OSU TRC, which provides engineering as well as testing services to a wide array of vehicles and regional vehicle developers.

13.0 Schedule

SARTA will implement the project over a 39-month schedule, which will include project kickoff in October 2017; development and procurement / installation of all proposed equipment, vehicles, and analytics capability between January and September 2018; initial (Phase 1, see Section 5.0) analytics development between October 2018 and March 2019; project demonstration and testing for 18 months ending in August 2020; and outreach, analysis, and reporting from April through December 2020. See Gantt chart (Figure 5; next page).

14.0 ITS Program and/or Innovative Technology Initiatives

DOT's ITS Program deploys wide-reaching research and innovation development in advanced transit and vehicle technologies. ITS deploys various transportation research technology initiatives that focus on providing transportation services to the underserved (especially persons with disabilities, veterans with disabilities, and older adults), development of advanced vehicle communications, and advanced vehicle technology standardization.

The project will draw on and strongly support ITS technology initiatives through demonstration of ridesharing programs that cater to underserved populations, including ITS target populations. The project will also focus on providing and demonstrating, under real-world conditions, new technology-oriented systems for managing multimodal transit systems that incorporate V2V, V2I, and associated modeling to optimize transit times and minimize environmental footprint. Connected vehicle technologies deployed under the project will be implemented in coordination with DOT, providing the opportunity to receive input from ITS regarding connected vehicle standards. Compliance with available standards information will help to ensure consistency with future anticipated smart transit systems deployments within SARTA's service area. Coordination with DOT will also provide the opportunity for project experience and lessons learned to be considered by ITS, as its connected vehicle technology standards are finalized.

		2017	2018				2019				2020			
Task	**Description**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
1.0	Project Management and Admin													
	Development, Procurement, Equipment Installation													
2.1	Development and Planning													
2.2	Vehicle and Equipment Procurement													
2.3	Vehicle Delivery													
2.4	Equipment, Analytics Delivery/Installation													
	Implementation and Demonstration													
3.1	Phase 1 Analytics													
3.2	Project Demonstration / Phase 2 Analytics													
3.3	Outreach, Analysis, Reporting													

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15.0 Staffing Description

15.1 Staffing Description

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	Steve Sokolsky	Program Manager	Project management, data, outreach	Y
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15.2 Primary Point of Contact

Name:	Levent Guvenc
Title:	Professor of Mechanical Engineering and Intelligent Vehicle Systems
Organization:	OSU CAR
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Phone:	614-688-1849
Email:	guvenc.1@osu.edu

16.0 Cost Discussion

For a project of this magnitude, which involves active participation of over 15 veteran professional researchers, transit authority managers, administrators, technology developers and managers, the proposed funding request from DOT of $2,810,584 is exceptionally reasonable to complete the diverse proposed goals, objectives, and tasks considered in the project. To this DOT contribution, SARTA and the project team will add a total additional match investment of $2,895,031 in local matching funds, supporting a total project cost of $5,705,615. Match funding will be sourced from existing and ongoing SARTA transit related revenues. Match funding provided by SARTA, which will total $2,186,867, will be sourced from local funds from an existing one-quarter of one percent local sales tax (0.25 or ¼%). This sales tax revenue covers approximately 80% of SARTA operating expenses, including program management and capital improvements. This funding is available now. Finally, SARTA has cash reserves of nearly $12 million to put into the capital budget if needed to cover any unexpected shortfalls. In addition to SARTA match, project team members will also contribute match to the project. Teradata will provide an in-kind investment of $100,000, based on partial donation of data management and analysis services needed to support the project. Partner Quasar will provide $300,000 in match as a wholly cash contribution toward the purchase of a gas system upgrade at the Zanesville Digester, needed to support the project. Finally, partner IMS will provide $150,000 in match funding, including a portion of the proposed smart paint and smart cane costs, wages, and rare earth synthesis and characterization. These funds are readily available within the proposed schedule outlined for the project. All match committed under the project is documented in the attached letters of commitment. Thus the project will strongly leverage local and state funds to stretch DOT's investment. See attached budget for additional detail.

The attached budget has been carefully designed to wholly conform to DOT's applicable uniform administrative requirements, cost principles, and audit requirements including those codified in Title 2 CFR §200.306(a-d, and f-k), and §200.414 on Indirect (F&A) costs. No volunteer services or contributions are considered, and all match funding complies with these requirements.

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